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12 February 1985

# USSR Report

MACHINE TOOLS AND METALWORKING EQUIPMENT

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12 February 1985

USSR REPORT  
MACHINE TOOLS AND METALWORKING EQUIPMENT

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INDUSTRY PLANNING AND ECONOMICS

BRNO MACHINE TOOL SHOW REVEALS CEMA COOPERATION

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 19 Sep 84 p 3

[Article by V. Rzhevskiy and V. Yaroshevskiy: "Limits of Integration. This Is Beneficial to All"]

[Text] On the outlining approaches to Brno, the guests are soon greeted by numerous posters proclaiming "Welcome to the 26th International Machinery Manufacturing Fair." We counted nearly 30 flags at the main entrance which is the number of nations represented at the Brno show of modern machinery manufacturing. Alongside the Indian Exposition is the Brazilian Pavilion; in a large steel and glass "tent," firms from Bulgaria and Australia, Hungary and Japan, Cuba and Holland demonstrate their products and their desire to cooperate.

It is gratifying to note the scope of socialist countries' exhibitions. In the year of the 36th anniversary of CEMA, interest toward them has heightened. The achievements of fraternal countries are particularly visible in the field of microelectronics, it is entirely correct to call microprocessors the catalysts of scientific-technical progress. It is precisely they, who in the coming years will be asked to provide a sharp turn in the direction of increasing labor productivity and the raising of the effectiveness of overall production. The controlling computer complex is exhibited in the branch of the soviet association "Elektronorgtehnika."

The scope of its application is broad, from automation of scientific research to formation of intellectual terminals and terminal stations--the developments are represented by the soviet specialist Nicholas Bogatyrev. The "smart" technology is the result of painstaking research of many collectives from socialist countries. Polish scientists developed the printing mechanism, their Bulgarian colleagues produced the accumulators on magnetic disks. The Hungarian developers placed the drums of the alphabet-numeric printing arrangement, specialists from the GDR the magnetic tapes, while the overall complex operates on the basis of the electric minicomputer "CM-1300." Compactness, reliability, functional simplicity, all these qualities are integral to the controlling computer complex.

Similar examples of mutually beneficial cooperation we encountered in the exhibition of the Hungarian "Vidioton" and of the well known GDR firm

"Robotron." The complex for automation of structural and design work was demonstrated by production employees of Czechoslovak factory of computer technology in the town of Banska Bistritsa.

We asked the Minister of Electro-technical Industry of the Czechoslovak SSR, Milan Kubata, to comment on what we had seen and heard:

--Cooperation with countries in the field of microelectronics is of paramount importance for Czechoslovakia. This is due to a number of reasons, not restricted to those of a production character. The American administration continues the policy of embargo, sanctions and limitations directed at governments of socialist collaboration. Reagan also exerts a rough pressure on the countries of Western Europe. Unfortunately not without results. For example, this year, the Swiss police did not permit passage across the border of a container with parts destined for the Czech SSR. Naturally this did not paralyze our industry. But you must admit that it is not possible for a branch of industry to operate under conditions of dependency on the whims of a Western partner.

Therefore further expansion of cooperation, the research for new forms of interaction with fraternal countries for Czechoslovak microelectronics is a question of particular importance. I would like to consider the cooperation with the USSR. Among the socialist countries, Czechoslovakia is the largest buyer of soviet computers. Presently 500 soviet computer complexes work effectively in our national economy. Future plans envision a joint creation of a unique microelectronic apparatus, for example testers, which by their complexity will resemble computers.

A notable detail, outside of high technical parameters, the demonstrated machines, machine-tools, attract attention by their external appearance. Specialists of many enterprises with whom we had occasion to converse, noted that they have been created in close cooperation with creators and designers. It is obvious that machines whose development requires a large output of hard work, are not created for beauty alone. However, the line of demarcation between the perfect and useful hardly exists. The creative research of specialists is directed toward the industrial production of convenient, practical and reliable machines and instruments.

Be certain to visit the machine-tool pavilion, advised us K. Svoboda, the general director of the Brno Machine-Tool Manufacturing Fair. Since progress in this field determines to a large extent the overall increase in the effectiveness of machinery construction as a whole and influences the quality and volume of machinery production for all branches of the economy.

A large pavilion actually resembled a factory of the future. Machine-tools worked noiselessly, whole complex lines, under the direction of microcomputers with an operational and long-range memory. It should be noted that branches of socialist countries correspond to each other, forming as it were a whole, offering the opportunity to get acquainted with the present-day technical level of this branch of industry in fraternal countries, specialists from USSR, GDR and Poland spoke of the machine-tool modules, which are utilized

in arranging the automatic sections in factories, about the automatic lines with rapid resetting work schedules, about the processing centers which have no counterparts in outside practical work. While characterizing the operating exponents in each of the branches of CEMA countries, it was invariably underlined that machine-tool builders have very close contacts. This is graphically demonstrated by the stand devoted to the interaction of the Moscow factory imeni Sergo Ordzhonikidze with the Czechoslovak factory "Tos-Kurzhim." For 26 years the collectives of these two enterprises have been successfully developing cooperation. That much has been accomplished during these years is evidenced by two soviet decorations "Badge of Honor," and "Order of International Friendship," on the banner of "Tos-Kurzhim."

Daily business discussions by representatives from various continents took place at the fair. Negotiations were carried out on contracts and transactions, which by initial estimates exceeded a billion Krons. The inspection of machinery construction in Brno, where the highest awards of the fair were conferred on over 50 exponents (three of which were from the Soviet Union) has been one more contribution to the expansion of mutually beneficial cooperation on our planet.

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INDUSTRY PLANNING AND ECONOMICS

ARMENIA MARKETS NEW DRIVE MOTORS FOR MACHINE TOOLS

Yerevan KOMMUNIST in Russian 9 Sep 84 p 2

[Article by K. Firsov, USSR State prize laureate and chief engineer of the All-Union Soyuztyazhstankoprom Production Association, USSR Ministry of Machine Tool and Tool Building Industry: "Charentsavanskiy Motors"]

[Text] The machine tool industry today is one of the basic sectors of the national economy and its development essentially drives the development of all other sectors. The basic mission of domestic machine tool building is to increase as productively as possible the output of machines with programmed control and metal processing equipment.

Machines with ChPU [numerical control] are precision equipment run with complicated programs and they therefore create a whole series of new demands both on the quality of construction and on the stock furnished and used in them. For example, to guarantee movement in the working parts of this equipment, heavy-duty elements with totally new qualities are needed. These systems guarantee the movement of the elements with extremely high speeds along a complicated path with micron accuracy.

Extended research showed that these demands are fully met only by electric drive motors based on low-speed, energy saturated motors with high moments, "high-moment motors". These motors eliminate the need for awkward gears. The high dynamics, reliability and beautiful manageability make electric motors based on high-moment motors irreplaceable both for mechanisms in conveyer-feed equipment and for complicated industrial robots.

The complex electric drives with high-moment motors are installed in any piece of working equipment: milling, turning, drilling equipment, presses, etc.

The work of the Charentsavanskiy Machine Tool Production Association [SPO] in developing and assimilating series production of complete electric drives with high-moment motors was dedicated to solving the mission of providing the industry with the necessary stock. This work was accomplished in close contact with the thyristor transformer development engineers. Gamma electric drives covering the power range from 0.7 to 5 kilovolts and providing regulated speeds with a range of more than 1:10000 were developed and assimilated.

The original design decisions allowed the development of articles meeting the requirements of the world's level of non-scarce material and stock use. Specifically, these electric drives are the world's only articles made with magnets having a low content of cobalt, a very scarce material.

The author's evidence defends a number of new solutions used in the electric drives. These electric drives are designed along lines that consider the future of today's world requirements and allow the development of equipment for the total automation of all cyclic operations. At present there is only one factory producing such articles in the country, in the Minelektrotekhprom [Ministry of Electrical Equipment and Power Machine Building], and it handles about 15 percent of machine tool builder needs. The remaining necessary quantities of electric drives are acquired through importation from both socialist and capitalist countries.

Therefore, the Charentsavanskiy Machine Tool Production Association's development and mastery of serial production of these articles uncovered fundamentally new possibilities for a sharp increase in the level of equipment produced both in this association and in machine tool enterprises in Armenia and the Transcaucasus as a whole.

In particular, Charentsavanskiy machines are modernized with regard to the use of high-moment motors and the project for the future highly automated machine is completed. Work on using electric drives in turning machines in Yerevan's Factory imeni Dzerzhinskiy and on the machines in Yerevan's milling machine factory has begun. The present production volume of electric drives at the Charentsavanskiy SPO allows them to meet totally the demand for these articles in all Transcaucasus enterprises.

At the present time, electric drives are used in more than 200 enterprises of various ministries, including equipment of the "processing center" type. Their use had a major effect on the national economy and further production expansion will allow the effect to increase many fold. Production of these articles at the Charentsavanskiy SPO is equipped with a complete complex of necessary stands and fixtures which guarantee the high quality of the article produced and also high production efficiency. This efficiency opens the possibility of increasing production without considerable capital investment.

Very significant results have been achieved as the result of the many years of creative cooperation between Charentsavanskiy machine tool builders and Cheboksarsk electricians and the united efforts of the representatives of the two sectors, machine tool building and the electrotechnical industry. The result of these efforts is the appearance of work that is of great importance to the national economy, work at the Charentsavanskiy Machine Tool Building Association in the development and assimilation of serial production of complex electric drive EKZM [expansion unknown] mechanisms with high-moment motors for feeding equipment with numerical control and industrial robots, deservedly nominated in the competition for the state prize of the Armenian SSR.

INDUSTRY PLANNING AND ECONOMICS

DEAN OF KIEV STATE UNIVERSITY ON IMPACT OF ROBOTS

Kiev POD ZNAMENEM LENINIZMA in Russian No 16, Aug 84 pp 67-69

[Interview with Academician of the UkSSR Academy of Sciences I. I. Lyashko, date and place not given: "To the Shoulders of the Robots"]

[Text] Until quite recently robots inhabited only the pages of science fiction novels. But today they have occupied operating positions at many plants and have become reliable assistants to people. The widespread use of industrial robots as a component of complete production automation has become an important trend in work to renovate all sectors of the national economy based on the modern achievements of science and technology.

Our correspondent asked the dean of Kiev State University imeni T. G. Shevchenko, Academician of the UkSSR Academy of Sciences I. I. Lyashko, to tell about the achievements of scientists in the development of robotics.

[Question] Robots came into being literally before our eyes. Nothing personifies the results of the scientific and technical revolution as strongly as they do. Just what are robots and what is their mission in modern production?

[Answer] The word "robot" was coined by the Czech writer Karel Czapek. In his play "Rur", written in the early 1920's, this is what he called the artificial people which were made at factories and then sold to mines, and plantations.

In the modern sense of the word, robots are a prospective means of complete automation and of solving pressing national economic and social problems, including the problem of manpower resources and improving working conditions. Robots differ from traditional means of automation primarily in universality, ability to switch quickly to performing new production operations, mobility and flexibility, which is especially important for series and small-caliber production.

Thus, a robot is an multipurpose automaton for mechanical operations. Human capabilities are an example in its development up to the present. The desire to find a substitute for man in performing operations which are monotonous and of little interest also gave rise at first to the idea of a robot, then the first attempts to realize it and, finally, to the emergence and development of robotics and robot engineering. As a rule, a robot consists of mechanical arms--manipulators, and a control unit which "gives them commands" automatically and is able to process and store information (for example, by means of an electronic computer). It can have sensory attachments--"organs of sense", as well as means of movement and unusual mechanical legs--pedipulators.

Industrial robots first began to be introduced into machine building. Today they are used in the mining, oil and gas, metallurgical and metalworking industries, construction and transportation, agriculture and medicine. Robots are also helping to develop the ocean and space. Robotics is rapidly developing and the essence of robots as fundamentally new types of machines is changing drastically.

True, we are as yet dealing with predominantly first-generation robots. These are manipulators with the same automatic, rigid-control program as, let's say, machine tools with programmed control and other automatic manufacturing equipment. However, they are rather versatile and serve many purposes since they are easily switched over to various manipulating process cycles in a wide range.

Although such very simple robots will also exist in the future, nevertheless, already by 1985 the greater part of them will be so-called second-generation adaptive automatons with a special system of "feeling", information processing and microprocessor control using digital computers. They are able--according to the program loaded in them--to adapt themselves to the various conditions of the production process and, in so doing, maintain optimum operation.

Later, by early 1990, third-generation manipulators with components of artificial intellect will be prevalent. These will be able to recognize an unknown or changing situation, automatically make a decision relative to its further actions in connection with its set production task, plan operations and produce control signals for realizing the plan.

One can also foresee both "self-instruction" of robots and their amassing of their own experience, in order to use it later in similar situations when performing other operations. It is precisely these kind which will replace a significant number of people in all sectors of the national economy who are engaged in laborious and monotonous work, say, in assembly and installation, control and inspection and adjustment operations.

We use the word "generation" in a specific sense. After all, the subsequent generations (adaptive and "intellectual" robots) do not cancel out the previous ones. Thus, programmed robots "will work" anywhere that simple and inexpensive machines are advantageous.



[Question] What is the effect of using robots?

[Answer] As experience shows, the comprehensive use of manipulators already assimilated by industry and still not very refined increases labor productivity two- to threefold on the average, doubles the shift system of equipment and improves product quality and overall production conditions.

A qualitatively new period in the development of robotics has begun in the current five-year plan--a period of its widespread use in the national economy. This is a typically intersectorial problem and all, without exception, machine building sectors must participate in solving it, each according to its own specialization, of course.

The first phase of production robotization is being completed at enterprises of the Ukraine. Since the beginning of the five-year plan the number of operating manipulators has increased from several dozen to 1,500 and in 1985 the number will reach 6,000. Precisely this kind of indicator has been taken as a guide for the republic program of assimilating series production and introducing into the national economy robots, manipulators and small-scale mechanization equipment in 1983-1985 and the 12th Five-Year Plan.

Series robots have already freed hundreds of people from laborious and monotonous work. The production associations Yuzhnyy Machine Building Plant imeni L. I. Brezhnev in Dnepropetrovsk, Novokramatorskiy Machine Building Plant, Zhdanovtyazhmash and Kineskop in Lvov, Vatra in Ternopol, Kommunist and Kristall production associations imeni S. P. Korolev and the Krasnyy Ekskavator and Leninskaya Kuznitsa plants in Kiev, the Starokramatorskiy Machine Building Plant imeni S. Ordzhonikidze and others have much experience in this.

Together with the development of production, improvement and widespread introduction into the national economy of modern first-generation industrial robots, in the current five-year plan we must organize production of subsequent-generation automatons--right up to robots with artificial intellect.

The systematic expansion of the sphere of the use of robotics systems is an important matter.

According to specialists estimates, robot-drillers in the extractive industry will not only sharply increase labor productivity (at least double or triple), but will also efficiently solve the problem of improving its sanitary conditions for hundreds of thousands of workers.

It happens that certain manual operations (on the conveyor, at machine tools, dies, ovens and so forth) cannot be mechanized and automated by the traditional means. But even if it is possible, it is not economical to develop a specialized automaton one kind of operation. Here is where a multipurpose manipulator robot would serve well, which can easily be changed over to various manual operation cycles. It performs not only all kinds of ancillary operations, but also many basic production tasks (assembly, welding, dying, etc.).



In speaking about the effectiveness of new systems, it should be emphasized that it is important not only to develop or purchase a wonder-robot, but also to be concerned with the serious, creative development of the most expedient system of manufacturing operations in the production section. It is precisely this consideration which provided the machine building enterprises the overall savings "recorded" in their robot shops.

Fundamentally new possibilities are coming to light in accomplishing complete automation and mechanization of production. Robotics is stimulating the formulation of new technical and organizational and other problems and is the very first element in the transition to a higher class of automation--from controlling individual units to developing flexible (readjustable) automated production facilities. The appearance of new equipment inevitably leads to the need for complicated and painstaking work to strengthen planning, manufacturing and labor discipline. For a manipulator does not understand why the billets are fed irregularly, does not want to deal with a substandard product, cannot compensatory leave at the beginning of the month and do rush work on the plan in the last 10 days....

[Question] Today, throughout the world they associate the next stage of the scientific and technical revolution with robotics. It has for our country, in addition to the economic and technical aspects, a great social significance.

[Answer] The transfer of physically hard work to the shoulders of machines, the reliability of labor safety practices and increasing the overall efficiency of man's labor activities signifies, as they say, the humanization of production. It conforms to the very essence of the society of mature socialism in which concern for man and for favorable conditions for his all-round development have been raised to the rank of state policy and legislatively consolidated in the Constitution of the USSR.

Another social aspect of robotics flows from the need to reduce the labor force if you take into consideration the demographic predictions for the coming years.

Finally, the appearance of robots in shops is posing new demands on the workers themselves. Now they have a higher cultural and educational level and, very importantly, high personal qualities (creative inclinations, initiative, boldness in making decisions, innovation). New industrial equipment helps erase the differences between mental and physical labor.

Thus, the need to speed up substantially the further development of industrial robotics is becoming increasingly obvious. However, this is not a simple task.

[Question] Exactly what do you mean?

[Answer] First of all, it is necessary to promote applied scientific and technical research and development of systems which are more improved both in construction principles and in manipulating characteristics and which, at the same time, are more effective from a manufacturing and economic standpoint.

Various types of research using large analog-digital complexes which model the behavior of real objects take on special importance. Digital computer equipment is connected both to robot control systems (especially microprocessor) and to equipment for their system designing (universal and control).

Secondly, intensive design developments of specific systems are needed to combine various industrial manipulation operations--simple and complex, less and more universal--according to a specific set of modules (mechanical, driving, electronic, computer, measuring, etc.). Perfecting such modules will make it possible to "implant" them in future components of artificial intelligence.

Thirdly, it is necessary to expand the componentry of robotics, miniaturize to the maximum all its assemblies, optimize their accuracy and dynamic and power characteristics and also increase substantially the level of producibility. So far, the known robotics systems, especially their drive systems (electrical and hydraulic), frequently are inadequate--both the motors themselves and mechanical and electronic equipment in the robot's "arm" joints. The same also applies to the various "feeling" pickups in the "arm's" hand. Here it is impossible to manage without researching the physical and bionic principles of operation for the purpose of increasing sensitivity and accuracy.

Electronic componentry has great successes in the miniaturization and integration of amplifying logical and computational functions. Systems for information processing, planning and programming operations and formulating control signals built into the robots incorporate the most modern achievements of technology. The modernness of second- (adaptive) and third-generation (with components of artificial intelligence) robots depends to a greater degree on them.

Fourthly, achievement of the corresponding effect is dependent on the comprehensive development of industrial robots together with other shop equipment and on a serious examination of the principles of organizing the manufacturing process in each specific sector of production.

[Question] No matter how perfected a robot is and no matter how wide a range of logical functions it performs, it is and will remain only a tool for man for the purpose of helping him complete specific tasks. A question arises in this connection: How will man "mix" with the robot in the process of his activities?

[Answer] It is an extremely urgent task to develop better forms of information for remote observation of the situation in the working zone and the status and movements of the robot and to support man's decision making with possible "prompting" by digital computers. In such a "dialogue" the robot, operating rather actively, enjoys the right of a "consultative voice". The final word belongs to man. Only in relatively simple cases and typical conditions is the robot granted independence. Man monitors its automatic functions and, when there is a need, makes certain corrections.

Another aspect of this problem is the development of the most convenient attachments for feeding to the robot control and pointing signals relative to

the decision made (levers, light pen, voice and so on). Here, of course, a unilateral execution of the command by the robot is not possible, but, on the one hand, the best interpretation of it according to the elements of sequence and, on the other, corrections by the robot itself thanks to the information of its "sensory" pickups (if man's control signals are not totally correct, are careless and can be harmful for manipulators, the subject of the work and so forth). This applies mainly to manipulation (arm) operations.

[Question] In time, robotics will encompass most aspects of physical and mental activities. This gives rise to apprehension among certain Western futurologists and philosophers. They say that technology carries a threat to civilization itself, for the robot can turn out to be smarter than man and will enslave him.

[Answer] Such assertions are absolutely unfounded. By themselves, like things built by man, robots are unable to play a social role, no matter how much they are perfected. It is impossible to view them isolated from man or, much less, opposing him. All of this is merely a tool of certain types of labor activities, a means with which man will be able to uncover more widely his capabilities. But the "capabilities" and "talent" of the robot lie in the fact that it "tirelessly" performs the same monotonous operations, "coolly" and "confidently" manipulates, say, red hot objects, ensures labor productivity, keeps track of the results of one or another operation, sees in the dark, reacts to ultrasound.... This is what makes it a helper in man's work.

[Question] Can it not happen that the robot will suddenly display altogether different characteristics than expected?

[Answer] Theoretically, it is impossible to limit the improvement of robots and the development of components of artificial intelligence. Thanks to the achievements of the scientific and technical revolution, many effective innovations have emerged, in particular, electronic integrated circuits, which were not expected 20 years ago. Also, not too long ago complex mental operations seemed practically not feasible in the sphere of automation and today they are being realized with success.

Thus, robots are boldly entering our daily routine.

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INDUSTRY PLANNING AND ECONOMICS

ALL-UNION MATERIAL RESOURCES CENTER SET UP

Moscow *EKONOMICHESKAYA GAZETA* in Russian No 36, Sep 84 p 8

[Article "All-Union Materials and Substances Center"]

[Text] A new machine has been designed and is being prepared for production. Where to obtain authentic information on the composition and properties of materials and their technical economic indicators in order to use in their design such specific materials as will make it possible for the new machine to be more reliable and efficient? All this data will be concentrated in a recently established All-Union Scientific Research Center on Materials and Substances (VNITsMV) of the Gosstandart. New and already manufactured materials will begin to be recorded here.

It will be possible to find out at the VNITsMV what the most modern initial materials for manufacturing parts, machines, devices and structures are available at present. What the composition of which substances are the most advisable for use in technological, power and other processes. This concerns primarily fuel, oils, lubricants, chemical reagents, heat carriers, catalysts etc.

Information received at the center will be constantly renewed. The basic goal is that data accumulated must, without fail, become the property of consumers among whom are industrial ministries, enterprises and standardization organizations. An automatic system for storing, scanning and reproducing data will make it possible to serve users very efficiently.

Successful and timely knowledge about the results of scientific research being done by academic, industrial institutes and vuz will become widely available immediately. According to the TsNIIproyektstal'konstruktsiya, the use of data on the elastic properties of structural steels in designing high precision metal structures will reduce their metal consumption and will save almost 200,000 rubles per year.

This year material producers and consumers, with the approval of the USSR State Committee on Science and Technology and the Gosstandart, will determine a list of recorded materials, their properties and indicators, establish an order for carrying out this work and for utilizing the data available in the national economy. Material recording in the VNITsMV will begin in 1985.

## INDUSTRY PLANNING AND ECONOMICS

### WORK AT MINSK SPECIAL DESIGN BURO VIEWED

Minsk PROMYSHLENNOST' BELORUSSII in Russian No 2, Feb 84 pp 10-12

[ Article by N. Margolin, sector manager, science secretary of the NTO Council of the Minsk SKB AL "For the 3000-th Year" ]

[Text] A group of workers in the Minsk Automatic Line Production Association imeni 60-letiya Velikogo Oktyabrya were awarded the USSR State Prizes for 1983 in Engineering. Among them were the following: G. V. Gorbunov, general director of the association; V. Ya. Linkevich, deputy chief engineer of the Plant imeni P. M. Masherov, G. G. Shpak, tool shop chief; V. V. Bondarchik, deputy chief; staff workers of the Minsk Special Design Buro of Automatic Lines; chief engineer A. V. Kudyanov, chief designer Yu. N. Tatarov, division managers S. I. Bortnitskiy and A. P. Teleshov, and sector heads A. S. Raptunovich and V. S. Uzilevskiy. For introducing progressive metalworking equipment created in the Association imeni 60-letiya Velikogo Oktyabrya prizes were also given to V. G. Galko, partkom secretary of the "Minsk Tractor Plant imeni V. I. Lenin" and M. V. Zybov, acting technical director of the Gorkiy Automobile Plant

Machine tool building is frequently called the heart of machinebuilding. This expression primarily concerns modern automatic lines, automatic machine tools and NC control.

The association's output is among the basic facilities used in the manufacture of automobiles, tractors and combines. Therefore, the brand of the Minsk Automatic Lines Plant imeni P. M. Masherov (the head enterprise of the association) is well known in such plants as GAZ [Gor'kiy Automobile Plant], ZIL [Moscow Automobile Plant imeni I. A. Likhachev], VAZ [Volga Automobile Plant] and KamAZ [Kama Automobile Plant]. The Minsk plant will manufacture parts for the "Don-1500" combine and for the new automobiles of the Kutais Automobile Plant. Our equipment is also used successfully abroad. This year, the ChSSR is one of the biggest customers of the Minsk machine tools.

An essential special feature of automatic lines and special unit machine tools is that, as mentioned before, being the basic means for automating mass production, they themselves are, at the same time, producers of single-unit production. One copy of each specimen of equipment is manufactured according to an individual plan, as a rule. This is simply explained: frequently one line can provide for the entire production program at the customer's plant. Thus, each customer means a new plan, new requirements and new designs.

The Minsk Special Design Bureau for Automatic Lines is called the brain center of the association. Technical policy is formed here, contours are outlined, working drawings of each machine tool, device and the automatic line as a whole are made. The drawings are not retained long on the boards of the drawing room but are sent immediately to shops to be incorporated in metal. The main problem of the special design bureau is to increase the productivity of designers and control the quality and technical standards of the manufactured equipment already in the design stage. The most modern and most efficient ways are selected to solve it.

We will consider the basic ones. Standardization is an important direction in the SKB [Special Design Buro] work. In the creative activity area, this is, first of all, the interchangeability of the assembly units and individual components, typicalization of technical solutions and arrangement of the automatic lines and unit machine tools. In the organization area, it is standardization of drawings and blanks, as well as the typicalization of interrelationships of production components. All this is regulated by enterprise and other standards, developed on the basis of many years of experience with manufacturing instruction norms of the association.

Challenging standardization gave impetus to the practical utilization of modern applied science. Designers of the Minsk SKB for Automatic Lines, as is well known, were one of the first in the country to apply in practice a system for the automated design of complicated machine tool units using computers, and subsequently -- automatic drafting machines and other electronic equipment. The SKB was awarded the Leipzig Fair Gold Medal and medals of all-union exhibitions. At present, planning-design documentation in the form of numerical tables do not perplex anybody.

After developing typical design solutions, it became possible to typicalize their representation. Such drawings are called "paste ons" and are used widely at the SKB. These can be pasted on drawing paper by designers showing not only units and parts, but also individual parts of the drawing (cross sections, etc.) The most important result of this improvement is a reduction in the volume of routine labor, freeing time for creative work, raising the quality of design documentation and, as a result, improving the quality of the plant output.

The principle of the machine tool builders at the design stage, as well as in manufacturing automatic lines and machine tools, is to produce modern equipment with the most modern facilities and methods. Specialists of the Plant imeni P. M. Masherov used advanced technology at all stages of the production cycle which made it possible to provide for the high quality of each individual part, unit, machine tool or automatic line as a whole, as well as to reduce manufacturing time and time for placing the equipment into operation. Taking into

account the individual nature of production, finished-product manufacturing sections were created in machine shops and group machining of parts was organized.

A considerable amount of NC equipment was developed at the SKB and manufactured at the plant for their own consumption. "Processing center" type machine tools were the bases for further improvement in the organization of production. Flexible automated production for fully machining average size flat parts and housing parts was used at the Plant imeni P. M. Masherov for the first time in the country. An NC computer controlled equipment complex manufactured according to SKB AL [Automatic Line] design is protected by a number of patents.

The high standard of design developments and the organization of production process are the basis of successes achieved by the collective of the association in creating special design equipment for comprehensive machining and assembling various machine parts. In the first stage, automatic lines are being designed to manufacture crankcases for driving axles -- the most important parts of the running gear of automobiles, tractors and other means of transportation. The Minsk Association became the main enterprise in the country for equipping plants with such equipment in the automobile, tractor and other industrial sectors.

Specialization imposes special responsibility on the SKB and plant collectives. Especially since automatic lines and unit machine tools must last for many years and their technical standards determine the quality and standard of the manufactured output. The machine tools and lines created today, obviously, will have to operate in the 21st century. This means that the standard of technical equipment in plants of the third millenium must be formed in our day.

What is the output of machine tools and automatic lines with the MZAL brand? These are, first of all, crankcases for driving axles which are large size housing parts with complicated configurations, which makes it difficult to automate their manufacture. Machining such parts includes many technological operations. The development of the equipment began with single machine tools and automatic lines. The first set for machining truck crankcases was designed on order by the Gor'kiy Automobile Plant. Almost simultaneously similar equipment was installed at the Minsk Tractor Plant imeni V. I. Lenin.

Due to the active creative participation of the GAZ and MTZ specialists the equipment was released in a short time for operation and worked reliably for many years, facilitating an uninterrupted output of automobiles and tractors. At present, improved second generation automatic lines have been developed for these enterprises.

However, looking back, it may be said that it is precisely at that time that the start was made on a large scale to implement an important national economic problem -- automation of mass production of large size parts with complicated configuration. As shops were equipped with automatic lines, greater demands



were made on machinebuilders on the level of automation and technological possibilities, as well as the reliability and service life of the equipment. To satisfy these demands, many technical and organizational problems were solved in the Association imeni 60-letiya Velikogo Oktyabrya. Considerable research and systematic investigation of operating equipment was done. The SKB and the plant developed and applied comprehensive technical measures and reorganized the above-mentioned design and manufacturing processes. In summarizing the experience of that work, the SKB specialists prepared books and manuals.

Modern equipment for machining crankcases for driving axles provided full machining and assembly operations of most complicated designs and technology of manufactured parts, and represents large complexes of automatic lines. They, along with machine tools, include many auxiliary devices that load and unload automatically, monitor machining actively, clean and wash parts and perform other technological operations. The manufactured equipment is furnished with manipulators, tilters and transporter-storage devices between lines and machine tools.

The designers developed typical arrangements for automatic lines that provide for maximum concentration of technological operations using progressive cutting and auxiliary tools, and modern control systems. New in principle technical solutions appeared in the process of creative research. The design of lines, individual installations and devices are protected by patents. For the first time in domestic machine tool building, equipment for machining crankcase parts reached and exceeded the level of leading foreign firms. A typical model LM274 automatic line for machining the driving axle beam for the "Moskvich" automobile, installed at the Izhevsk Plant, was exhibited at the Leipzig Fair and was awarded a gold medal.

At present, dozens of automatic lines developed in our association are in operation at machinebuilding plants. They made it possible to improve the organization of production, reduce labor, free thousands of workers and save millions of rubles.

High productivity equipment for the Volga Automobile Plant, the automobile giant on the Kama, the Minsk Tractor Plant and other agricultural machinebuilding enterprises -- these are landmarks of the technical progress of the Minsk SKB and Automatic Lines Plant imeni P. M. Masherov.

Ahead of us are new still more responsible problems. Comprehensive equipment for manufacturing new models of domestic automobiles, tractors and other machines must be created. The SKB collective is preparing and implementing a program to raise the technical standard, reduce power, metal consumption, and use the latest electronic equipment in control circuits and progressive tools. The basic goal is to free man from heavy and monotonous work and transfer it fully to the shoulders of machine tools.

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## AUTOMATED LINES AND AGGREGATED MACHINING SYSTEMS

### PRODUCTION TURRET LATHE RETROFITTED WITH ROBOT

Moscow STROITEL'NYYE I DOROZHNYYE MASHINY in Russian No 7, Jul 84 pp 7-9

[Article by V. A. Petrov (VPKTIstroydormash [All Union Planning, Design and Technological Institute for Construction and Road Machinery]: "A Robot Engineering Complex based on a Semi-automatic Turret Lathe"]

[Text] The robot engineering complex (REC) was developed for the machining of a standardized part, in this case, union nipples of various types and sizes (Figure 1). The blanks have one threaded end and one hexagonal end.

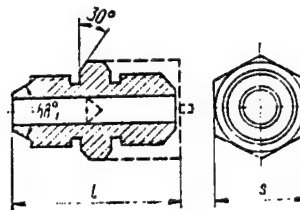


Figure 1. Part (hatched lines show blank contour)

The robotization of the process made it possible to use a modernized semi-automatic turret lathe to automatically machine the hexagonal part.

The 0.2 kg blanks were loaded by a RF-201M automatic manipulator with horizontal arm movement and vertical (up to 50 mm) column movement. In view of the limited movement of the robot hands, and based upon ergonomic, operational and other engineering requirements, the robot was vertically arranged over the lathe's headstock, transforming the arm's horizontal movements into vertical ones. With this arrangement, the robot arm holding the blank moves downward and aligns it with the chuck axis, while the threaded part of the blank is inserted into the chuck by a horizontal movement of the column.

The time required to machine one part (about 2 minutes) made it essential to use a 25-45 blank storage unit.

The need to machine several types and sizes of blanks, the difficulty of automatically readjusting the orientation device, the need to visually monitor the blank, and the length of the part's machining cycle led to the selection of a storage unit with electromagnetic drive and tray type manual loading. For blanks up to 55 mm long a two trough vibrator tray with pneumatic cylindrical movement from one trough to the other, autonomous drives for each trough and opposing movements of blanks was used.

The blanks are moved from one storage unit trough to another by a pneumatic cylinder with regulated walls and a plunger which serves as a set-up unit for blank length.

The storage unit is adjusted for blank length by changing the walls, and for hexagonal dimensions by moving it along plates attached to the machine tool. The unit can be moved along a bracket to set it at the required height relative to the spindle axis.

The REC includes a modernized turret lathe (based on a model 1K341) a RF-201M robot, a blank storage unit, a stripper, mandrel and other auxiliary devices.

#### SPECIFICATIONS

##### Robot Engineering Complex

Time to load part, seconds	7
Blank dimensions (lxs), mm	
Minimum	25x17
Maximum	52x30
Blank weight, kg	0.2
Storage unit loading	Manual
Number of troughs in storage unit	2
Storage unit capacity	25-45
Operating time on one loading of unit, hours	1.5
REC adjustment time, hours	0.3
Outside dimensions, mm	
Floorspace	Does not exceed lathe size
Height	1880

##### Turret Lathe

##### Base machine tool

	General purpose
	Model 1341 (or 1K341)
	turret lathe
Cycle time, seconds	30-1800
Control	Automatic
Control sytem	KEP-12U electro- mechanical command unit
Carriage drive	Hydraulic
Turret rotation drive	
Empty	Hydraulic
Full	Mechanical
Hydraulic drive working pressure, MPa	2-2.2
Circuit voltage	
Power	220
Control	220/24
Voltage of SD-54 program control motor	127
Speed of carriage and turret drives , m/min	1.2-1.5

## SPECIFICATIONS

RF-201M

Lift capacity, kg	0.2
Number of arms	1
Number of free movements used (with grasp)	3
Positioning error	±0.25
Movements, mm	+1.36
Arms	200 -1.65
Column	50 +0.45
	-0.82
Movement time (arms, column), seconds	0.75
Type of drive	Pneumatic
Pressure in air lines MPa	0.4-0.6
Programmer	Electromechanical
Continuous operation, hours	16

The REC works semi-automatically on blanks and carries out a sequence of steps. To do this, the base model 1K341 turret lathe was equipped with a number of additional devices. These include a component for engaging the carriage feed and for its longitudinal movement, a turret lock pin, position index, accelerated rotation and rotation interlock, a transponder, manual feed control engagement unit, brake and program devices and a hydraulics panel. [See Figure 2.]

The blanks are inserted into a three jaw adjustable chuck with threads matching its own. The blanks are reliably attached to the chuck by a threading device consisting of a ball-type coupling which comes into contact with the hexagonal blank's threads. The device is mounted on a centring drill in the turret's first tool station. If the blank to be machines is cylindrical, then a smooth jawed chuck is used.

The part is removed by a stripper mounted in a free socket in the turret. The stripper is a cylindrical, hollow unit attached to its mount by a spring. When the turret rotates, the support interacts with the bracket on the turret body, the cover opens up and the part moves from the stripper, along the tray, to a package mounted on the lathe.

The part is ejected from the stripper by a knock-out unit mounted on the chuck. The knock-out unit is a semi-sprung housing with detachable pins, with a diameter corresponding to that of the blank's inside diameter. When installed in the chuck, the blank is slipped over the opening by a pin and later, up against the housing face, it compresses the spring. When the chuck jaws are opened, the spring pushes the part into the stripper. From there it moves along the tray to the package.

The remaining REC devices and mechanisms are installed on the upper and vertical surfaces of the lathe's feed box.

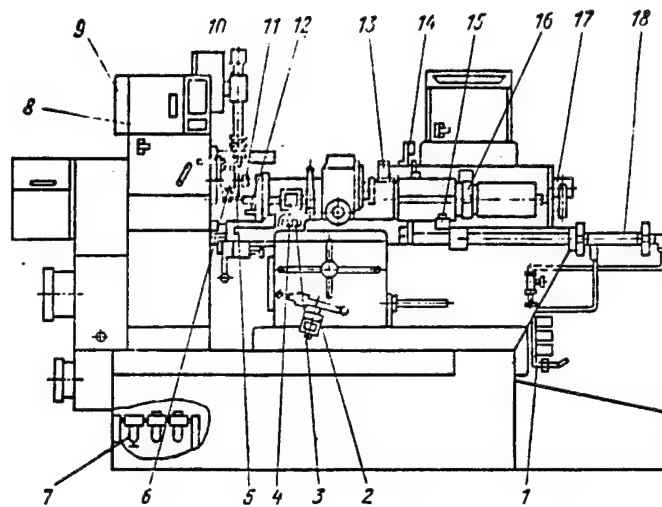


Figure 1. Model 1K341 turret lathe equipped with additional devices for use as a robot engineering complex:

1. Hydraulics panel. 2. Carriage drive engagement device. 3. Sensor. 4. Turret catch device. 5. Three jaw chuck. 6. Vibrator tray. 7. Compressed air unit. 8. Program device. 9. Distributor. 10. Manipulator. 11. Threading unit. 12. Stripper. 13. Turret interlock. 14. Turret indexing device. 15. Feed control engagement. 16. Brake. 17. Accelerated turret rotation unit. 18. Carriage movement unit.

The automatic manipulator is installed in a welded bracket and has its own manipulator, distributor and air compressor block. Three manipulator movements are used: arm extension (vertical), column extension (horizontal, along the lathe spindle axis) and contraction -- release of grasp.

The manipulator is equipped with tong grasps and a set of interchangeable jaws. The control of grasp position along the spindle axis is made possible by a dove-tail type device. The grasp has a semisprung clamp preventing the blank's movement when it is fed into the grasp.

A disengagement switch prevents the lather from being turned on when the arm is inserting the blank.

The distribution device is a cam operated command unit controlling the work of all REC devices and components, as well as the lathe. The device is also equipped with a pneumatic throttle with a reverse valve. The manipulator control panel is externally mounted on the lathe control unit. The air unit is on brackets on the lathe bed. Electromagnetic drive vibrating troughs are used.

The blank position sensor is a shaft with two lobes. One of them comes into contact with the blank in the tray and the other with a microswitch. The control of lobe position depends upon blank size.

An air cylinder located on the storage unit outlet controls the feed of blanks into the manipulator. The piston has a groove, which is a continuation of the storage tray. The body of the cylinder has a movable plate serving as a support for the flow of blanks and which assures the alignment of the blank axis with the manipulator arm axis during the conversion to blanks of different types and sizes.

Prior to start-up the blanks are manually placed in the storage unit. When the lathe is turned on, the blank feed air cylinder goes into operation and moves a blank, which is restrained by a spring installed on the manipulator arm grasp. Then the manipulator drive is turned on. The arm moves horizontally towards the blank. The blank is grasped and moved in a reverse direction, after which the arm moves to the extreme low position to align the blank and chuck axes. The storage unit feed air cylinder simultaneously rotates to starting position. If a threaded blank is being worked, a threaded collet chuck is used. In this case the chuck jaws are tightened and the manipulator column presses the threaded end of the blank to the slowly rotating chuck, screwing it in. The grasp opens and the manipulator arm returns to the initial position, the lathe is shifted to working speed and machining begins. When the centring drill is turned on, the ball coupling attached to it comes into contact with the blank and screws it on to the support in the chuck if that was not done by the manipulator. If the blank has a smooth surface, then a smooth jawed chuck is installed. The movement of the column towards the chuck causes the blank to compress the knock-out spring. The chuck jaws are then tightened and machining begins.

When the manipulators are working, the storage unit drives are in operation. After 3-5 seconds the blank movement air cylinder moves and returns to its initial position. This puts a blank into the front trough of the storage unit and frees it after a blank has moved through it. Upon completion of machining the stripper mounted on the turret drops down to the part. The chuck jaws open and the knock-out mounted in the chuck pushes the part into the stripper. During the machining of the next part, when the turret rotates the stripper support engages the bracket on the turret housing. This opens the stripper window. The part falls into the removal tray and into its package. Operating experience with the REC shows that its effective use is possible with fully loaded two shift operations. One operator in the third skill category is necessary for 5-6 REC's and a set-up man in the fifth category for 6-8 REC's. The operators fill the REC storage unit with blanks, engage it, observe its operations, bring empty packages and haul away full ones, when necessary clean the chuck, selectively monitor accuracy and clean up the work site. The section set-up man supports REC operation, readjusts the machine tools and other devices during the conversion to another part and performs simple repairs. The readjustment to another type and size of part involves the adjustment of storage unit trays, the adjustment of the following: the storage unit to the required height, depending upon the size of the blank to be worked, the rear wall of the storage unit mounted on an air cylinder, the moving plate support and blank feed cylinder and the position of blank sensor lobes, changes chuck jaws, manipulator tongs and chuck knock-out. The time required to readjust the REC does not exceed 30-40 minutes. The annual economic effect with full loading of the REC in two shift operation amounts to 8,000-10,000 rubles.

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ROBOTICS

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SPECIFICATIONS, APPLICATIONS OF GANTRY ROBOTS VIEWED

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 7, Jul 84  
pp 4-6

[Article by engineers V. I. Tsarenko, V. A. Popov, V. P. Sobolev and  
P. I. Ovchinnikov "Series of Industrial Gantry Robots"]

[Text] The ENIMS [Experimental Scientific Research Institute of Metal-Cutting Machine Tools] developed a series of industrial robots (PR) of the gantry types with a load capacity of 160-kg of unit design for use with a broad product list (up to 88 models) of modern metal-cutting machine tools for various technological purposes with horizontal or vertical disposition of spindles, as well as machine tools with a horizontal table. The basic specification of the PR are shown in Table 1.

The standard unit design of the PR makes it possible to finish off better the basic design solutions of functional units, making them more reliable and inexpensive, as well as grouping them according to the customers wishes. Series production of the standard unit design will begin in 1985.

Twenty functional unit subassemblers make it possible to group five various PR modifications. The PR grouping arrangement is shown in Table 2.

According to preliminary calculations, various PR modifications of unit design can service 37 models of lathes, 5 milling-center drills, 3 vertical drilling, 13 boring, 16 grinding, 9 gear cutting and 5 milling machine tools built in series by the machine tool and tool industry.

Based on the analysis and dimensions of the working zones of machine tools and the PR, the number of machine tools serviced by one robot, the dimensions of a machine tool along its length, width and height, as well as the possibilities of incorporating them into a robotized technological complex (RTK) and additional auxiliary equipment (conveyors, storage units, etc.), ten versions have been developed for a supporting system of column locations, four versions for column heights (2500, 3000, 3500 and 4000 mm) and four versions of the column design. This makes it possible to service all above-indicated metal-cutting machine tools, including also large-size machine tools as, for example, the IR800MF4, (6885 x 3750 x 3450 mm), IR500MF4 (6000 x 3750 x 3100 mm) processing centers; the model 3M174 (6620 x 3100 x 2100 mm) grinding machine

tool, etc. The components of the supporting systems are optimized from the viewpoint of applied loads, metal consumption, as well as the ease of their manufacture and are standardized with respect to size and connecting dimensions.

№ п/п	(16) Параметр	(17) Модификации ПР МА160П				
		41.01	01.01	51.41	51.01	81.01
1	Грузоподъемность, кг	160				
2	Число рук, шт.	1				
3	Число обслуживаемых станков, шт.	1-4				
(4a)	Число степеней подвижности без движения губок схвата В том числе:	3	4	4	4	4
		2	3	3	3	3
(4b)	управляемых от системы ЧПУ	2				
5	Максимальный ход каретки, мм	15850	15850	15850	15850	16500
6	Вертикальное перемещение руки, мм	590	590	590	590	—
7	Угол поворота рук, градус	—	—	105	105	90
8	Скорость перемещения рабочих органов, управляемых от системы ЧПУ, м/с:					
(8a)	каретки	1,2				
(8b)	руки	0,8				
9	Привод ПР	Гидравлический (18)				
10	Точность позиционирования, мм	±1,5				
11	Время смены схватов, мин	1				
12	Наибольший диаметр транспортируемых заготовок, мм	(19) Валы до 160				
13	Масса только манипулятора, кг	8600	Флан- цы до 400 8790	8900	Флан- цы до 400 8800	(20) 8250
14	Наибольшая длина транспортируемых заготовок, мм	(21) До 1400				
15	Габариты ПР, мм:					
	длина	18000	18000	18000	18000	18610
	высота	4830	4830	4830	4830	3850
	ширина	2000	2159	3000	2993	2300

Key to Table 1. 1. Lifting capacity; 2 -- Number of arms, pieces; 3 -- Number of serviced machine tools, pieces; 4 -- Number of degrees of mobility without motion of the grip jaws; 4a -- including: NC; 4b -- controlled simultaneously; 5 -- Maximum stroke of carriage, mm; 6 -- Vertical displacement

Table 1 continued:

of arm, mm; 7 -- Rotation angle of arm, degrees; 8 -- Speed of actuators controlled by the NC system, meters/sec; 8a -- carriage; 8b -- arm; 9 -- PR drive; 10 -- Positioning accuracy, mm; 11 -- Time for changing grips, min.; 12 -- Largest diameter of transported intermediate products, mm; 13 -- Weight of manipulator alone, kg; 14 -- Longest transported intermediate products, mm; 15 -- PR dimensions, mm: length, height, width; 16 -- Parameter; 17 -- Modifications of PR MA160P; 18 -- Hydraulic; 19 -- Shafts up to 160; 20 -- Flanges up to 400; 21 -- Up to 1400.

Unit design PR are controlled by positional NC systems that makes it possible to implement various working cycles, while the PR working zone makes it possible to use them to service a group of machine tools within an RTK.

The PR is equipped with a wide range of quick-change grips for solid of revolution parts. A possibility is provided for changing grips automatically. The grips are equipped with built-in sensors to monitor the basing correctness of the part on the machine tool, as well as with a sensor to determine the position of the parts located on the transportation system.

The PR electrical circuit is a light protection device to provide for the operating safety of the service personnel.

The kinematic arrangement of the PR model MA160P.51.01, which is the basic one in the developed series, is shown in Fig. 1a. Carriage 1 moves over monorail 2. The carriage is moved by a step drive through a hydraulic actuator. The movement is transmitted through level gears to a rack and pinion which engages another rack. The drive contains an additional transmission which serves to select the play in the engagement of the rack and is connected to hydraulic engine 4.


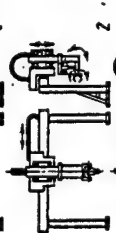
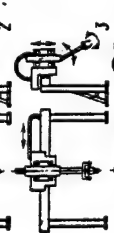
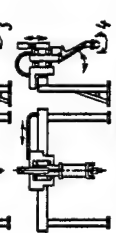
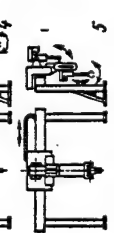
The hydraulic actuator and the hydraulic engine are tied into one system.

Frame 5 is mounted on carriage 1. Slide block 6, connected to the rod of the linear electrical-hydraulic drive 7, moves in frame 5 on roller contact bearings. Arm 8 made in the shape of a lever, is attached at the end of the slide block rocking around a horizontal axis. This movement is produced by linear electrical-hydraulic step drive 9, mounted on a bracket attached to the slide block.

A straightening device, consisting of a system of levers and serving to move the head forward is attached to the arm, i.e., for preserving the vertical position of the spindle at any position of the arm. The device has fingers 10, two of which are fastened rigidly to frame 11 and two are fastened to disc 12 which is connected with splines to pins of head 13. The fingers are connected to rods 14 and make up an articulated parallelogram.



Table 2

(6)	(7)	(8)	(9)	(10) (11) (12) (13)										(16)				(19)	
	Модификация ПР	Назначение	Компоновка ПР	Опорная система	Керетка		Привод Керет- сун	Рука				Схваты		Датчики адаптации		(17)	(18)	(19)	(19)
№ п/п					1-й вариант	2-й вариант	1.4.1.1.7.1.000	1.0.1.4.7.1.000	1.12.4.7.1.000	1.2.1.4.7.1.000	3-й вариант	Головка	для валов Ø40-100	для валов Ø100-160	для валов Ø200-400	для валов	для фланцев		
1	01.41	Обслуживание стан- ков с горизонтальной осью шпинделя в крупносерийном про- изводстве		+	+	-	+	+	+	-	-	+	+	+	-	+	-		
2	01.01	Обслуживание стан- ков с горизонтальной и вертикальной осью шпинделей, а также станков с горизон- тальным столом в се- рийном производстве		+	+	-	+	+	+	-	-	+	+	+	-	+	+		
3	51.41	Обслуживание стан- ков с горизонтальной осью шпинделя в се- редкосерийном и се- рийном производстве		+	+	-	+	+	+	-	-	+	+	+	-	+	-		
4	51.01	Обслуживание стан- ков с горизонтальной и вертикальной осью шпинделей, а также станков с горизон- тальным столом в се- рийном производстве		+	+	-	+	+	+	-	-	+	+	+	-	+	+		
5	81.01	Обслуживание стан- ков с горизонтальной осью обслуживания в мелкосерийном и се- рийном производстве		+	-	+	-	-	-	-	+	+	+	+	-	+	-		

Key to Table 2 on next page.

Key to Table 2.

1 -- For servicing machine tools with horizontal spindle axis in large series production; 2 -- Servicing machine tools with horizontal and vertical spindle axes, as well as machine tools with a horizontal table in series and large series production; 3 -- For servicing machine tools with a horizontal spindle axis in small series and series production; 4 -- For servicing machine tools with horizontal and vertical spindles axes, as well as machine tools with a horizontal table in series and small-series production; 5 -- For servicing machine tools with a horizontal servicing axis in small-series and series production; 6 -- PR modification; 7 -- Purpose; 8 -- PR arrangement; 9 -- Supporting system; 10 -- carriage; 11 -- carriage drive; 12 -- slide bar; 13 -- arm; 14 -- version; 15 -- Head; 16 -- Grips; 17 -- for shafts; 18 -- for flanges; 19 -- adaptation sensors.

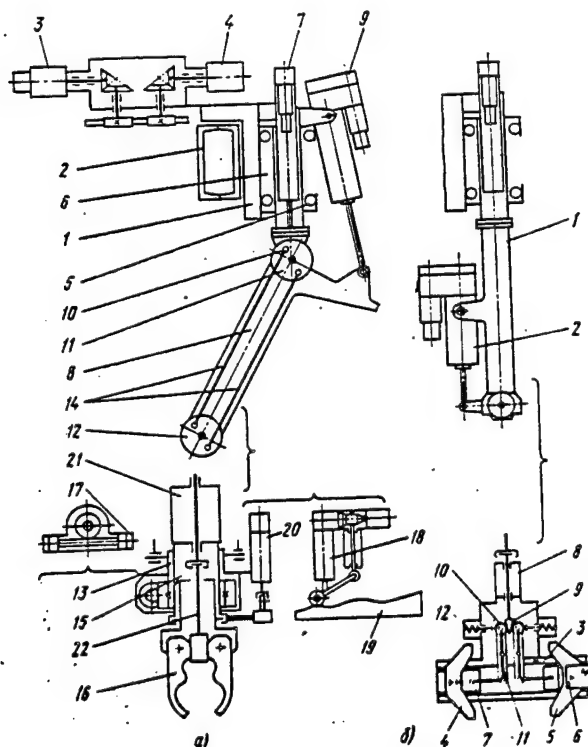


Рис. 1. Кинематическая схема портального ПР:  
а -- мод. МА160П.51.01; б -- мод. МА160П.01.01

Fig. 1. Kinematic arrangement of the gantry PR: a -- model MA160P.51.01, b -- model MA160P.01.01.

The head is hinged on the end of the arm and has spindle 15 to which grips 16 are fastened. The spindle rotates around the vertical axis by  $180^\circ$  and has an intermediate stop point (canting at  $90^\circ$ ).

The spindle head is turned by hydraulic cylinder 17, controlled by slide valve 18. The probe of the following slide valve makes contact through the lever with ring contour follower 19, fastened to the head spindle. The lever axle is fastened to the pull rod which rests on stepped rod 20 of the auxiliary three-position hydraulic cylinder. Depending upon the position of the rod, the lever axle can be set at one of three levels, which leads to a change in the position of the following slide with respect to the contour follower and, therefore, to the rotation of the cylinder. Each level of the lever corresponds to a certain point in the spindle stop.

The jaws of the grip are moved by hydraulic cylinder 21, through rod 22. A two-sided rack, which engages gear sectors, cut on the grip jaws, is fastened to the end of the pull rod.

Another kinematic arrangement (Fig. 1b) of a PR unit design (model MA160P.01.01) differs from the arrangement described above.

Arm 1 is rigidly fastened to the end of the slide block. A head, which can rotate  $90^\circ$  around a horizontal axis, is attached to the arm. This movement is produced by linear electrical-hydraulic step drive 2, installed on a bracket attached to the arm.

A two-sided grip for parts of the flange type, with a diameter of 200-400 mm and more complex kinematics, can operate with an industrial robot of this modification.

Frame 3 of the grip has guides on both sides for two pairs of slide blocks. The part is clamped by two prismatic jaws 4 and 5. Jaw 5 is set in ring 6 and is self-adjusting. To readjust the grip for other part diameters, jaw 4 and ring 6 that have grooves, can be moved to corresponding grooves of slide block 7 to the needed position and fixed in that position.

When the hydraulic cylinder rod moves, pull rod 8 connected to it through valve 9 makes contact with rollers 10 installed on rockers 11. The rockers rotate around their axes, clamping springs 12. Rocker rotation moves the slide blocks hinged on them. This causes the jaws to come together and clamp the part.

The part is unclamped on the reverse stroke of the hydraulic cylinder. Springs which are in the compressed condition return the grip jaws to their initial position.

The design is made for a comparatively small stroke of the jaws and, when using parts that have a great difference in external diameters, different sides of the grip are used whose jaws are adjusted to the corresponding dimensions.

The hydraulic system of the robot moves the carriage on a monorail, moves the slide block, rocks the arms of the MA160P.01.01, turns the head spindle along with the grip, and actuates the clamping and unclamping of the jaws.

The industrial robots of the described series are controlled by a model UPM-331 NC system with magnetic tape. The control program is written in the form of individual frames. The immediate-access memory contains a maximum of 32 frames. Each frame contains geometric data (final positions of three programmed coordinates), the speed of movement of the actuators, the number of external technological equipment being connected (technological instruction), the indicator of its operation, instructions for clamping and tilting, and the program for transition instructions.

The most advisable form of using unit design PR in production is to include them in RTK, i.e., create independently acting systems; an industrial robot, a group of automatic or semiautomatic machine tools and a set of auxiliary equipment that would provide fully for an automatic work cycle within the complex and its relation to the input and output flows of the rest of the production facility. The RTK is an independent production cell capable of solving various technological problems.

By using RTK, tied in with transportation facilities and, at a higher level -- controlled by computers, it is possible to create readjustable automatic lines, sections and shops that can machine single-type parts comprehensively.

Automatic sections designed with RTK have the following advantages.

1. The use of the PR automates materials handling of machine tools, transportation of parts between machine tools within the RTK and, when necessary, the reorientation of the parts;
2. It is possible to design RTK and sections from a wide list of models series produced semiautomatic machine tools;
3. RTK sections have a flexible organization of structures, i.e., it is possible to adjust them for operation in the automatic line mode (characteristic for large series and mass production), as well as in independent machine tool operation mode, characteristic for small series production.
4. Depending upon specific production requirements, automatic RTK sections can be manufactured in different designs, preserving the general technical solutions: in the form of individual RTK "robot-group of machine tools," equipped with devices for tying the complex to the input and output of the basic production facility; in the form of comprehensively-automated sections, consisting of several RTK, including an automated warehouse, a department for preparing tools and their delivery to the machine tools, a quality control station, etc. The design of the section control system can also be varied: from dispatcher operation of the machine tools within the RTK and a robot control system to section control within several RTK by a control computer.

5. It is possible to design RTK sections and improve them stage-by-stage to the required capacities.

6. It is possible to execute a number of additional operations: measure the diameter or length of the intermediate product before it is loaded into the machine tool; reject intermediate products with unallowable deviations of dimensions; provide uniform distribution of shaft tolerances when machining on center-milling machine tools; clean bases of parts and fixtures; monitor correctness of intermediate product basing in the machine tools; select random machined parts for quality control automatically; search for and identify intermediate products for the initial position in the section and automatically package machined parts at the final position in the section; change grips automatically, etc.

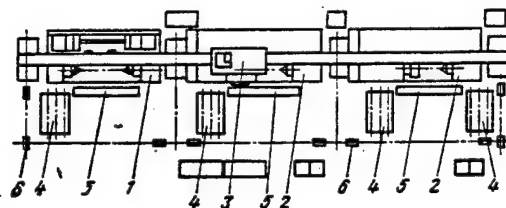


Fig. 2. Arrangement of RTK for turning shafts.

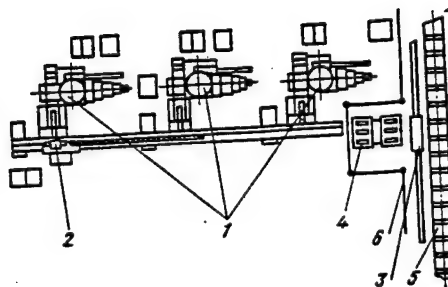


Fig. 3. RTK for machining housing parts.

Complexes shown in Figs. 2 and 3 are examples of using unit design industrial robots included in RTK.

Fig. 2 shows a complex designed for the automatic lathe machining of shafts weighing up to 160 kg in series production. The complex includes the following: model MR179 center-milling machine tool 1; two model 1B732F3 lathes 2; industrial robot 3; magazines 4; intermediate loading positions 5 and a light protection system 6.

The PR in the complex execute the following operations: load and unload machine tools; transport between machine tools; rearrange intermediate products and parts in magazines. The intermediate products are oriented in the magazine and the PR executes the search for the intermediate products and the distribution of the parts in the magazine.

Fig. 3 shows a complex for machining housing parts (for example, housing for hydraulic units) weighing up to 160 kg. It includes model 500MF4 processing center 1, industrial robot 2, stacker crane 3, rotary table 4, warehousing-storage unit 5 and fencing 6.

The intermediate products of parts are delivered to the rotary table from the warehouse-storage unit in special packing by the stacker-crane. The rotary table transfers the packing to the robot servicing zone. The PR loads the machine tools, transfers the parts from operation to operation in the automatic mode and returns the machined parts to the warehouse-storage unit through the rotary table.

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2291

CSO: 1823/85

ROBOTICS

ROBOTIZED BLANKS LOADER FOR NEW FORGE PRESS

Leningrad LENINGRADSKAYA PRAVDA in Russian 21 Sep 84 p 1

[Article "Robot -- Blacksmith's Apprentice" by LentASS]

[Text] Many industrial sectors need large size forgings from castings weighing more than 200 tons. Such is the output of a special design automatic forge complex in the "Izhorskiy zavod" Association. A 6000 ton press, manipulator robot, forging crane, thermal furnaces and other equipment are designed to operate in an automatic coordinate mode "dictated" by a computer. An operator uses control knobs only when special design intermediate products are manufactured, while in executing series produced parts, he only keeps an eye on the correctness of the actions of the mechanical "arms."

The Izhorsk workers organized this complicated equipment half a year ahead of schedule, thereby increasing the productivity of labor by 1.2 percent above the plan and reducing production costs by 0.6 percent. For this purpose, the worker brigades were trained to operate the new equipment in the process of its installation and adjustment; they organized a sort of school of advanced experience during each shift change, analyzing each other's successes and failures.

Increasing the productivity of labor in industry by better utilization of fixed production capital is one of the directions of the "Intensifikatsiya-90" Territorial Sector Program. "By implementing it, the workers of the Izhorsk Plant, one of the largest machinebuilding enterprises in the country, are modernizing at an accelerated rate. All metallurgy is being reequipped: new casting equipment is being installed; a "5000" rolling mill, the largest in the country, is being built; a most powerful 1000-ton press is being modernized. This work will make it possible for various sectors of industry to use whole large size intermediate products with uniform quality of metal, instead of welded ones that are labor-intensive in manufacturing.

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ROBOTICS

FLEXIBLE APPLICATIONS ROBOT USED IN MOSCOW TRAINING COURSE

Moscow SOTSIALISTICHESKAYA INDUSTRIYA IN Russian 1 Sep 84 p 3

[Article by L. Selyunina "Hello, Robot!" (Moscow)]

[Text] Today, the first group of robot adjusters in Moscow are beginning studies in the 148th professional-technical school in the capital. They already know where they will work: the famous AZLK--Automobile Plant imeni Leninskiy Komsomol. The situation is that this enterprise is the first in the Union to change over to flexible technology with the wide use of robot equipment.

Thirty graduates of the eighth class were selected for this group. By the way, the competition here was more intense than in many technical vuz. It is still not completed. Instructors keep an eye on the students and will retain only the most proficient. The others will be transferred to other professional technical groups, since this school trains workers in many specialties.

A special course on robot equipment is first on the schedule.

"This is also a first lesson for me," stated I. N. Dmitrevskaya, the author of the special course. "In general, our group is experimental. Even the name of the specialty is not yet approved. The official list of professions contains astronauts, but no robot adjusters. We prepared the training program together with plant engineers. Of course, even today the AZLK has such adjusters. But, as a rule, they are graduate engineers who learned about robot equipment independently, while we will have to see whether it is possible to train yesterday's eight-year classmen in three years to become skilled specialists and, in addition, give them a full secondary education."

We entered the laboratory where a very modern "Betta" robot, made at Togliatti, was installed. N. Sh. Karabayev, master of industrial training, a newest equipment enthusiast explains:

"It can drill, weld, move heavy objects, cut, saw and weave. Yes, essentially, it has no limitations. If desired, it can even tip a hat and greet newcomers and wave handkerchief to students when they leave."



So far, it cannot do any of these. In three years, the students will learn to prepare programs and fill the robot's brain with them, as well as heal its ailments. However, before they become on "thou" terms with it, they must master physics, mathematics, technical esthetics, chemistry, metallurgy, and study all types of robots. The students will gain sound practice first in the excellent shops and laboratories of the school and, in the second year of the course, in the AZLK shops. Each student will be assigned to a trainer engineer. Briefly, he will be at home at the plant."

The plant will be their second home also in another sense. Starting today, the students have a right to all the good things the AZLK can offer. Yuriy Bulayevskiy can, for example, continue his rowing sport; Sergey Aksenov, who played football in school, has a chance to join a plant foremen team. There are 28 sections of the plant's sport palace and dozens of the palace of culture societies at the disposal of the professional technical school. Obviously, the students cannot imagine working at an automobile plant and not being able to drive a car. When they reach the proper age, they will be able to complete driving courses under favorable conditions.

...At the minute, the first bell rang, in the professional technical school, another 70 specialists of the same trade began studying at the Moscow Automotive Institute.

"Out of third year students, we formed the first groups of engineers in the country working on operating robots and flexible automatic production facilities," stated B. V. Shandrov, dean of the Technology and Automation of Machine-building. "The graduates will begin to work at the AZLK mostly as robot adjusters."

In three years, they will meet in the shops. Some will complete professional technical school, while others will graduate from the institute, but the profession will be the same. Then, it will be seen who is worth what.

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PROCESS CONTROLS AND AUTOMATION ELECTRONICS

UDC 658.512.011.56

CONTROL SYSTEM OF COMPLEX CNC MACHINING CELL

Moscow MEKHAIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 6, Jun 84  
pp 27-29

[Article by engineer T. M. Yavid: "Control System for Fully Automated Numerical Control Machine Tool Cells"]

[Text] The ASK-20 type fully automated cells are designed for machining base members. The ASK-20 cell consists of a group of NC machine tools, a machining center with accumulators, a conveyor system, an automated storage unit with stock-piling machine, worker positions for loading (unloading) parts, an accessory assembly department, a tool preparation department and a control system.

The parts being fed into the cell are placed in the storage unit. A storage unit cell can store one or several parts of the same description, a fixture, accessory table, an empty tray and a set of tools.

During machining on the cell, a part undergoes two to four operations (passes) on NC machine tools, returning to the storage unit after each operation.

Parts are machined in fixtures which are assembled on accessory tables from universal assembly tooling to fit each operation for each batch of parts. The part is secured in the fixture at the loading station, and with the help of the conveyor system is placed in the machine tool's storage unit. A worker secures and releases the parts in the fixture. The parts are transported between the loading (unloading) stations and the accumulators and between the accumulator and the machine tool automatically. The average machining time of a part during one pass on the machine tool (under one control program) is no less than 1 hour. The storage unit ensures independent operation of the machine tool for an entire shift without human participation. This makes it possible to organize three-shift operation of the cell with two-shift operation of primary production personnel. Only duty personnel are left for the third shift.

The first ASK-20 cell, called the Talka-500 GPS, with a control system developed by the TsNIITU (Central Scientific Research and Design-Technological Institute for the Organization and Technology of Control) was put into operation in 1982 at the Ivanovskiy Heavy Machine Tool Plant imeni 50-letiya SSSR. This cell included 4 Modul'-500 units, 1 model IR 800MFCh machine tool,

automated storage for 182 PZhA-119 cells, a production preparation cell and a control system based on the SM-2 computer. The control system provides coordinated operation of all units of the cell.

The system encompasses control of the following production process units: NC machine tools, the conveyor system, the blank storage unit, the production preparation cell and worker positions at the loading (unloading) stations.

The basic principles in developing the control system include:

formation of a unified informational cell model, adjustable in a real-time mode and serving as the basis for accounting, dispatching control and direct control of the units;

predominantly automatic input of information, but when man is a necessary link in the production process (for example, at the loading station), combining information input with production operations;

structuring the system in the form of functional modules (tasks), interconnected via arrays and integrated into a unified system by a central control module which organizes joint operation of the functional modules, ensuring they are called in the necessary sequence.

The dynamic model of the cell consists of the following models: storing the status of the loading (unloading) stations, the status of the machine tools and accumulators and the status of the rack of the finished parts.

The model the storage unit status is an array containing a record of each storage cell--a code of the contents of the cell and requisitions. With each load received and sent out at the storage unit, the record of the corresponding storage unit cell changes.

The model of the loading (unloading) station status contains complete data for each station on the batch being loaded--a code of the part and operation, the number of parts loaded in the batch and for the shift, the number of unloaded parts at the loading station, plan requisitions and certain ancillary data needed for calculations.

Similarly, the model of the machine tool contains current and plan data of the batch being machined.

The model of the machine tool accumulator status contains data on all batches of parts located in the accumulator. There may be from one to three batches of parts in the accumulator; accordingly, the model of the accumulator status consists of three records, part of which may be blank.

The model of the finished parts rack contains a part and amount code for each batch. Each time parts are loaded, machined, unloaded and fed from the storage unit to the loading station and back, a change is made to the corresponding arrays.

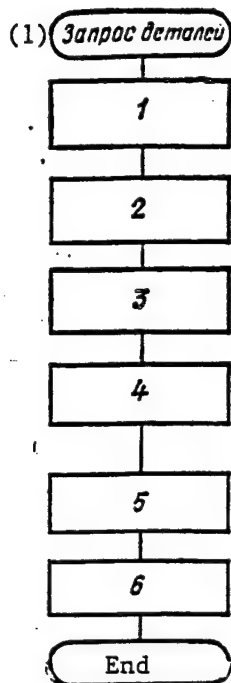


Figure 1

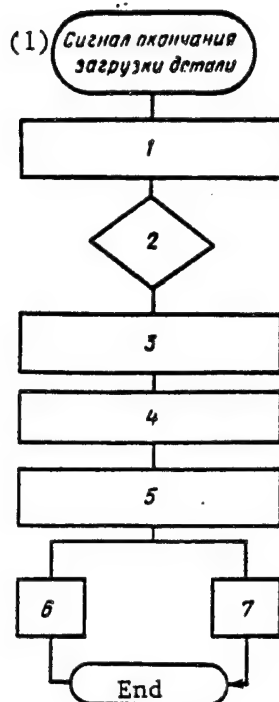


Figure 2

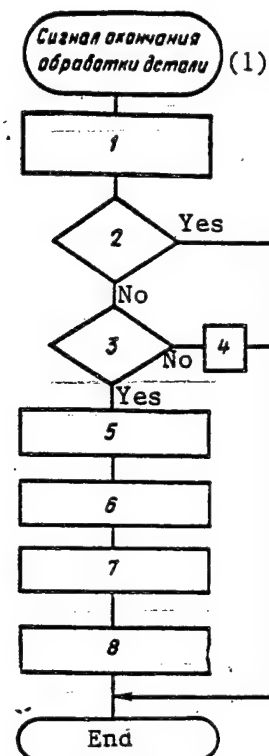


Figure 3.

Figure 1. Control algorithm for delivery of part to loading (unloading) station: (1)--request for part; 1--identification of the code of the part and operation by the model of the station; 2--search of address of necessary cell by the model of the storage unit; 3--generation of commands to stock-piling machine; 4--movement of stock-piling machine, process control computer complex (UVK) performs other tasks; 5--load is delivered, UVK receives signal to execute command; 6--change of the storage unit model.

Figure 2. Control algorithm for loading (unloading) station: (1)--signal of completion of loading part; 1--changes in station and machine tool model; 2--number of parts loaded is compared to planned load; 3--indication in accumulator model on the end of batch loading; 4--formation of message to calculation task; 5--entry to station status model for loading of next batch; 6--transmission of command to feed tool to the tool department panel; 7--transmission of message to station panel.

Figure 3. Control algorithm of the machine tool: (1)--signal of completion of part machining; 1--correction of model of machine tool and accumulator status; 2--blanks are in the accumulator; 3--loading of batch is completed; 4--message on idle time of machine tool for loading; 5--formation of message to accounting task; 6--entry of next quota into model of machine tool status; 7--search for control program in library; 8--delivery of control program to machine tool.

The complex of unit control tasks ensures automatic delivery of fixtures and blanks from the storage unit to each loading station in accordance with the shift quota at the rate of work of the loading station operator and generation of commands to the tool department for delivery of the tool to the machine tool when a batch is changed. Enlarged flowcharts of the control task work algorithm are shown in figures 1-3.

The complex of calculation tasks keeps track of the work of the machine tools and loading stations for the shift, the parts turned out from the cell, the passing of orders, prepared tool sets, assembled fixtures and idle times.

The complex of communications tasks between the UVK with its units and the personnel of the cell ensures collection of information from the contact sensors, collection of information from the manual information input consoles and output of quotas to production personnel in a real-time mode.

The complex of operational and schedule planning tasks provides an estimation of the cell's requirement for tools, special fixture components and blanks for the month, estimates of equipment utilization and a plan-chart of part production on the cell for the month and estimates work plans of cell subdivisions for the week and daily quotas for loading and machining parts and for tool and fixture preparation.

The system's complex of technical equipment consists of a standard SM-2 computer complex supplemented with external memory units, a display, internal and external communication devices and devices for communication with the object; data input consoles and an information display panel.

Data input consoles are installed at each loading-unloading station, at work places of loading blanks into the storage unit and delivery of finished parts from the cell and in the fixture assembly department and tool department.

Information display panels are installed at work places of loading parts into the fixtures and in the tool department.

The worker's quota for loading parts is output to the loading station panels and the commands for feeding a tool set to the machine tool are output to the tool department panel.

Information on requests from the storage unit and delivery to the storage unit of blanks, parts, fixtures and empty trays, information on the assembly, disassembly and output of tool sets and other information is input from the data input consoles.

In 1983 the Ivanovskiy Machine Tool Production Association began circulation of the ASK-20 cells to a number of the country's enterprises. The cells differ in the number and type of machine tools (Modul'-500 units and IR-800 machine tools), the type and capacity of storage units and conveyor systems, the type of NC systems and other characteristics related to the differences in production organization at the various enterprises. These differences do not permit using one control system in all ASK-20 cells. The experience of developing the ASK-20 cell for the Ivanovskiy Heavy Machine Tool Plant and an

analysis of the structure of cells of this type make it possible to isolate standard elements in control, facilitating circulation of control systems for these cells.

Two methods were used to isolate standard elements: analysis of the structure of the cells for the purpose of identifying the functional elements of control recurrent in various cells and analysis of the control system in order to identify elements which are functionally different but have similar algorithmic solutions.

Based on the analysis made, a set of algorithmic modules was developed, with program implementation of them on SM-2 and SM-4 computers, including:

a central control block, ensuring communication between tasks in a real-time mode and organization of message queues;

a sensor information acquisition block forming messages according to the signals arriving at the UVK input from sensors installed on the object;

an information acquisition block from data input consoles for the receipt and formation of messages coming from the input consoles, building queues of messages received and sending operator prompts to the input console;

an address storage unit control block, ensuring running of the storage unit model, search of the cell with the prescribed contents in the storage unit model, running request queues and giving the operator reference data on loads existing in the storage unit;

an accounting block, designed for counting the prepared tool sets, prepared fixtures, tracking the work for the shift, forming models of the finished parts rack, accumulator, the blanks area, parts put out from the cell and other similar functions characterized by the formation of lists, indicating the number of each component of the list differing from others by requisition indicators;

an idle time monitor block for computing the idle time for the day and the shift;

a report and document output block, providing a variety of machine readouts; a block for running correction arrays, providing entry and correction of various files. All these blocks are made taking into account common requirements, making it possible to join them in various combinations without changes, and then design systems from standard blocks with the addition of non-standard ones and gradually supplement the set with new developments, without changing the earlier developed standard blocks.

The system's flexibility is achieved owing to the following basic principles: the functional blocks are independent; communication between the blocks is accomplished by the central control block by sending messages. The blocks are set up for specific conditions of use (the number of machine tools, the capacity and structure of the storage unit, the types of reasons for idle time

and the method of inputting them, the number of input consoles and composition of messages and others).

The existence of standard blocks makes it possible to reduce the labor-intensiveness and time of developing ASK-20 cell control systems.

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## PROCESS CONTROLS AND AUTOMATION ELECTRONICS

### PRODUCTIVITY GAINS THROUGH CAD OF CNC PROGRAMS

Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 5, May 84  
pp 10-12

[Article by Candidate of Technical Sciences V. A. Bakhvalov: "Computer Aided Design of Programs for Numerically Controlled Machine Tools"]

[Text] For small-series and series type production facilities, the main means of automation is the use of numerically controlled (NC) machine tools. The inventory of NC metal-cutting machine tools is steadily expanding and the machine tools are being improved. Production sections and NC machine tool shops are being built. Such sections and NC machine tool shops are the basis for developing flexible automated production facilities. Rapid changing of processing programs, production flexibility and, at the same time, an increase in productivity is ensured thanks to the use of NC machine tools. Based on the experience of using NC machine tools, it has been established that the savings in labor expenditures reaches 25-80 percent and one NC machine tool replaces from 3 to 8 manually controlled machine tools. The proportion of machine time increases and labor productivity increases to 50 percent. The time to manufacture a product is reduced by 50-60 percent. The cost savings of designing and manufacturing technical equipment is 30-80 percent. The degree of precision in manufacturing parts increases several times over in individual instances and the number and cost of lapping operations decrease to one-fourth to one-eighth.

Along with the listed advantages, there are also shortcomings. Numerically controlled machine tools are relatively expensive and the preparation of control programs requires considerable expenditures of resources and time. Today, systems for computer aided design of control programs (CAD-CP) are widely used in our country for the purpose of reducing the labor intensiveness and increasing the quality of preparing control programs for NC machine tools.

A comparative analysis conducted by the Parma Scientific Production Association of 150 CAD-CP's, including 59 foreign ones, showed that the existing CAD-CP's can be divided into three levels according to the level of automation:

the first (lowest) level CAD-CP, at which a computer performs a limited amount of calculations, is mainly a mathematical and analytical programming of the geometric parameters of the process, but all technical decisions are predetermined by the process engineer;



the second (middle) level CAD-CP makes it possible to let the computer solve not only geometric problems, but also individual stages of the process preparation (selection of the blank and roughing cuts according to the correlated instructions of the process engineer, selection of the cutting tool, cutting conditions, etc.);

the third (highest) level CAD-CP, at which the computer solves both geometric and process problems.

To ensure the third (highest) level of automating the process of preparing control programs, it is necessary to reduce the task of the initial data to a recording of only the geometric dimensions in a standardized form from the drawing of the workpiece. Minimizing the initial data, along with sharply reducing the time for recording and keying, makes it possible to increase substantially the probability of obtaining an efficient control program which does not require graphic checking and correction on the machine tool.

Thus, the current trend is to combine CAD-CP with CAD of production process planning and, on this basis, develop complete systems which include CAD-CP of the second (middle) and third (highest) levels of automating the process of preparing control programs. A further increase in the level of CAD-CP automation involves the emergence of new computer equipment and the expansion of the manufacturing capabilities of NC machine tools.

The basic characteristics of CAD-CP are: purpose according to machine tool groups; programming language; computer orientation; tasks performed.

According to machine tool groups, CAD-CP's are divided into those for machine tools with contouring or positioning NC systems. The former are for milling machines, lathes and electrical-discharge machines and the latter--for jig-drilling, boring and other machine tools. A considerable number of CAD-CP's are designed for programming 2.5 coordinate machining of flat, varied-height contours, passing from contour to contour according to the third coordinate (for example, the SAP-2, SAPS-M22, SPS-F, SPPS, SAPS, Tekhtran, SAP-Yes and SAP-SM). For bulky three-coordinate machining, the SAP-3, Iskra, ART, ACTION and other CAD-CP's developed for three-coordinate machining mainly perform tasks of geometric design and keying control programs, and only some of them, such as the Iskra CAD-CP, perform process tasks. The CAD-CP's for milling machines make it possible to reduce the labor-intensiveness of preparing control programs to one-tenth to one-twentieth and lower the cost to one-fifth to one-fifteenth.

From 1 day up to several weeks is needed to learn the CAD-CP language. Preparation of the source program in the CAD-CP language takes on the average between 30 minutes and 1 hour. Computer machine time for processing a program of average complexity takes 30 seconds to 10 minutes.

Universal and specialized CAD-CP's differ. Universal CAD-CP's are suitable for preparing control programs for machine tools of various process groups or for machine tools of a specific process group, but of a different type. In our country, the following universal CAD-CP's are widely used:

SAP-3, SAP-4, SPPS and others for milling machines and profile-grinding machines;

SPSTAU, TAU-T, SPS-TT and others for lathes;

Tekhtran, Fialka, Iskra, SAP-SRFT, SAP-Yes, SAP-SM, Sadko, SAP-ChPU and others for various groups of machine tools.

Universal CAD-CP's ensure the possibility of a unified approach and a unity of requirements in preparing control programs for various groups or types of machine tools and make it possible to automate complex geometric and, in a number of cases, process designs as well. Shortcomings of universal CAD-CP's include: the considerable volume of initial data; insufficient efficiency in preparing a control program and correcting it; the inability to judge beforehand the results of the source program processing. Furthermore, the time allotted for work on a computer is limited and the desire for universality of the CAD-CP results in the complication of the programming language which increases the probability of errors in the source program.

Specialized CAD-CP's are suitable for performing highly specialized tasks (engraving inscriptions and marks on panels, machining cams, blades, printed circuit boards and other things) for a specific combination of machine tool numerical control units. They include the Graver SPN, SPUP-AU, SPDP, SAPS-PP and SAP-3. Specialized CAD-CP's have a number of advantages compared to universal ones, namely: simplicity of operation; the possibility of more complete use of the system; a considerable decrease in cost due to the reduction in the size of the system, limited by the conditions of the tasks; the possibility of making process decisions and optimizing their selection. In addition, the majority of these systems are realized on small computers which ensures the efficiency in preparing control programs.

The languages in which the geometric and process data on the part and billet is described are different. Tabular, textual and mixed languages differ according to the method of presenting the initial information.

In tabular languages, all information is disseminated according to units of a pre-compiled form (table). In so doing, a number of concepts are encoded which is connected to the complication of the recording, a reduction in the clearness and an increase in the labor-intensiveness of compiling the control program. But a strict correspondence between the type of information and its position in the table simplifies building the system and saves placing it in the computer's memory. In addition, tabular languages are convenient when describing process information.

Under the textual method of tasking the source program, the data on the part and blank is recorded in phrases, close to conversational. Textual languages are easily and quickly learned, which affects the time it takes to learn the system. However, textual languages are complicated for translating into machine language. The diversity of textual languages lies in the methods used for assigning geometric elements, in the symbols, words, expressions and operators used and so forth.

Further development and improvement of languages follows the path of consolidating the tabular and textual methods of tasking source programs which considerably expands the capabilities of assigning and solving process tasks.

The next characteristic of CAD-CP's is their orientation on a specific family of computers. In our country, systems have been developed realized on computers of the Nairi, Mir, SM, M-400/5000/6000, Minsk and YeS families. Today, the most developed systems are oriented on YeS computers (DOS and OS) and SM computers (OS RV). It should be noted that most CAD-CP's realized on large computers operate in a batch mode. In so doing, the efficiency of preparing control programs decreases. The CAD-CP's realized on small computers provide a higher efficiency of control programs as a result of their operating in an interactive mode.

Tasks performed by the CAD-CP's are divided into geometric, process and service-organizational tasks.

Geometric tasks include: calculating geometric elements; calculating the reference point coordinates of the contour relative to the overall center; calculating equidistances; forming contours and point systems; transforming elements and contours; calculating dimension chains; calculating pointwise and analytically assigned curves; automatic rounding off of a shape and others.

Process tasks preclude the formation of process commands. In completing process tasks, one must take into account a multitude of factors of a process and economic nature which requires the development of data banks for CAD-CP's.

Service-organizational tasks include diagnosis of syntactical and semantic errors during multiple compilation; formation of control program outlines; keying of control program outlines; listing source and control programs and graphic control of control programs; correcting source and control programs in the interactive mode.

As a rule, CAD-CP programs are structured according to a preprocessor-processor-postprocessor pattern.

The functions of the preprocessor include the translation of the source program into machine language. In addition, the preprocessor is used for standard manufacturing processes or classes of parts and for automating individual route processing method elements.

The processor serves for completing general geometric, manufacturing and service-organizational tasks. The system processor also accomplishes two types of control: syntactical--checking the correctness of recording the source program according to the rules of the CAD-CP language; semantic--checking the correctness of assigning the movement of the tool, i.e., an understanding check of the source program. Given the presence of errors in the source program, they are diagnosed. The results of the operation of the CAD-CP processor are produced in an intermediate language CLDATA which are usually not dependent on the characteristics of machine tool numerical control units. The CLDATA data consists of a series of X, Y and Z coordinates of the center of the cutting tool in its sequential positions and production process

commands which are only input into the appropriate place in the program. The availability of the results of the processor operation in the CLDATA language expands the field of application of CAD-CP's in the direction of developing postprocessor libraries which convert the results of the processor operation (CLDATA data) into control program outlines for specific machine tool numerical control unit complexes.

The postprocessor accomplishes the following: a read-out of the processor data from the CLDATA language; translation of the data into the machine tool's coordinate system; translation of the data into absolute values or increments; a check on the limitations of the machine tool; an output of outlines of feeds and speeds and positioning commands; selection of the interpolation method; output of control programs of the corresponding type, format and code on punched tape; a print-out of control program texts; diagnosis and print-out of errors. The postprocessors are developed either as special-purpose for a specific complex of machine tool numerical control units or for a whole series of machine tools with a specific system of numerical control units.

By the field of application of CAD-CP's, we mean the possibility of automating the preparation of control programs for specific complexes of machine tool numerical control units and the totality of tasks to be performed. The field of application is determined by the presence of a CAD-CP postprocessor and by the tasks performed.

A rather important problem which is solved in building or selecting a CAD-CP is the possibility of its adaptation to the manufacturing conditions of a sector of industry. Selection of the CAD-CP depends on a number of factors:

the need for control programs and the diversity of NC machine tools;

the complexity of parts and manufacturing processes;

the availability and workload of computers or the possibility and convenience of leasing computer time from another enterprise;

the preparedness of specialists of the enterprise to conduct work on automating control program preparation;

consideration of the prospect of developing an inventory of NC equipment.

The NC machine tool sections and shops being established and operating at enterprises of the Ministry of Instrument Building, Automation Equipment and Control Systems, as a rule, have in their composition machine tools of various manufacturing groups (lathes, milling machines, drills, etc.) with a great diversity of numerical control unit racks (about 30 types of numerical control unit racks). In this connection, use of universal CAD-CP's of the second (middle) level of automation of control program preparation for the various manufacturing equipment groups is the most feasible under the conditions of NC machine tool section operation. The greatest number of parts machined at the abovementioned sections fall in 6-9 groups of complexity and represent either a body of revolution, a combination of flat varied-height contours, or a combination of bodies of revolution combined with flat varied-height contours.

It is most feasible to prepare control programs for machining similar parts with the help of CAD-CP's designed for 2.5 coordinate machining and realized on YeS or SM computers.

The CAD-CP's oriented on large computers operate in a batch mode, but the computer are under the authority of the computer center and a process engineer-programmer's access to them is limited in time. Therefore, the efficiency in preparing control programs decreases. The CAD-CP's oriented on small computers, specifically on the SM-4, operate in the interactive mode and as a result the efficiency in preparing control programs increases. However, it should be kept in mind that the increase in efficiency of control program preparation is achieved only when the small computer is available directly in the subdivision engaged in developing the control program. When computers (SM-4) located directly in sections of NC machine tools and which are performing control functions of the latter are used for preparing control programs, the efficiency of control program preparation falls sharply. In the event of a lack of a small computer in the subdivision for preparing control programs, it is more advisable to use CAD-CP's oriented on large computers, specifically on YeS computers. For the purpose of rapid assimilation and putting into industrial operation, it is feasible to use CAD-CP's with a simple language for describing the source program.

Indicator	SAP-YeS	SAP-SM	Iskra YeS	Iskra SM	SAP-ChPU
Type of system (1)	2.5 координатный язык текстов. Возможна обработка некоторого класса объемных деталей. Перфокарты, перфолента, магнитная лента. Similar to SAP-YeS				
Information carrier (2)	Similar to SAP-YeS				Punched Tape
Amount of input info. Postprocessor	Up to 40,000 characters Invariant	Up to 30,000 characters Invariant	Up to 30,000 characters Invariant	Up to 30,000 characters Invariant	Postprocessor library
Area nesting	YeS-1022/23	SM3/SM4	YeS-1022	SM4	YeS-1022
Number of conversions	160 Кбайт ДОС (3)	32 Кбайт ОСРВ (4)	200 Кбайт ДОС (5)	60 Кбайт ОСРВ (6)	256 Кбайт ДОС (7)
Computer type and required memory	200 Кбайт ОС	256 Кбайт ОС	256 Кбайт ОС	256 Кбайт ОС	256 Кбайт ОС
Operating mode	Batch	Interactive	Batch	Interactive	Batch

Key:

1. 2.5 coordinate text language. Machining of a certain class of bulky parts is possible.
2. Punched tape, punched cards, magnetic tape
3. 160 kilobytes, DOS (Disk operating system)
4. 200 kilobytes, OS (Operating system)
5. 200 kilobytes, DOS
6. 60 kilobytes, OS RV
7. 256 kilobytes, DOS

The following CAD-CP's most fully correspond to these requirements: SAP-YeS, SAP-SM, Iskra SM, SAP-ChPU. Basic technical characteristics of these CAD-CP's are listed in the table.

The CAD-CP's listed in the table have identical manufacturing and operational capabilities. However, the SAP-ChPU's have the simplest programming language. This makes it possible to reduce substantially the time for learning the system (to 8-10 days). Presently, a SAP-ChPU is in the trial operation stage at the Aktyubrentgen Production Association. This system is realized on a large YeS-1022 computer in DOS. Work is being done at the Parma Scientific Production Association on translating the system into OS.

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TECHNOLOGY PLANNING AND MANAGEMENT AUTOMATION

MODELS OF OPTIMIZATION OF BRANCH PLANS FOR AUTOMATION OF MANAGEMENT

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[Abstract] This article continues two earlier works by the author on construction of a plan for creation of an automated management system in a material production industry. This article further develops and summarizes the results produced in the earlier works. The primary tasks which must be performed in composing a branch plan for automation of management are selection of objects for automation, variants of AMS and times of creation of systems for individual facilities. The optimality criterion is the maximum overall economic effect. The models described by the equations presented in this article are nonlinear, but can be converted to integer linear programming models by increasing the number of variables. An example of this conversion is presented. The practical implementation of the model suggested involves a number of methodological, informational and computational difficulties. However, the experience of application of the optimization approach in development of automated management systems demonstrates that the difficulties can be overcome. References 8: 7 Russian, 1 Western.

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